and/or claims by the current Amendment. The attached page is captioned "**<u>VERSION WITH MARKINGS TO SHOW CHANGES MADE.</u>**"

It is noted that the amendments are made only to more particularly define the invention and <u>not</u> for distinguishing the invention over the prior art, for narrowing the scope of the claims, or for any reason related to a statutory requirement for patentability.

It is further noted that, notwithstanding any claim amendments made herein, Applicant's intent is to encompass equivalents of all claim elements, even if amended herein or later during prosecution.

I. THE CLAIMED INVENTION

Applicant's invention, as disclosed and claimed, for example by independent claim 1, and similarly claims 58-61, is directed to an electrically conductive layer having a copper alloy, which includes at least one of <u>Ag, As P, Si,</u> Bi, Sb, and Ti at not less than 0.1 percent by weight. <u>The copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. The copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight</u>. (See Page 10, lines 13-19; Page 16, lines 5-10; Page 19, lines 16-24; Page 20, lines 16-20; and Page 21, lines 6-16).

In similar second embodiment, as disclosed and claimed, for example by independent claim 12, <u>the copper alloy further includes at least one of Ge and Mg in a range of not less than 0.1 percent by weight to not more than a maximum solubility limit of copper</u>. (See Page 19, lines 16-24).

In a third embodiment, as disclosed and claimed, for example by independent claim 22,

the semiconductor device includes a semiconductor substrate, an insulation layer over the semiconductor substrate, and the insulation layer having a trench groove, a barrier metal layer on a bottom and side walls of the trench groove, and an electrically conductive layer provided in an interconnection layer on the barrier metal layer, and the interconnection layer filling the trench groove. The interconnection layer comprises a copper alloy which includes at least one of Ag, As P, Si, Bi, Sb, and Ti in a range of not less than 0.1 percent by weight to not more than a maximum solubility limit to copper, so that said copper alloy is in a solid solution. The copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. The copper alloy further includes at least one of Ge and Mg in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. (See Page 10, lines 13-19; Page 16, lines 5-10; Page 19, lines 16-24; Page 20, lines 16-20; and Page 21, lines 6-16).

Devices depict interconnection structures formed in semiconductor devices of various materials, including aluminum, and with different structural dimensions and arrangements. However, a device generally has a trench groove with a narrow width, which "suppresses the growth of the copper crystal grain, whereby the copper crystal grain is likely to have a small size." The small size of the crystal grain allows existence of many crystal grain boundaries reducing the reliability of the interconnection and the yield of the semiconductor device. (See Page 5, lines 19-22; and Page 6, lines 1-5).

An important aspect of the copper alloy is that it includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight. Further, the copper alloy also includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. The copper alloy further includes at least one of Cr and Ni in a range of not

less than 0.1 percent by weight to not more than 1 percent by weight. In the second and third embodiments, the copper alloy could include at least one of Ge and Mg in a range of not less than 0.1 percent by weight to not more than 1 percent by weight or, alternatively, not more than a maximum solubility limit of copper, instead of Cr and Ni. These features suppress the mass-transfer of copper through the copper alloy and prevent the resistivity of the copper alloy from becoming too high. (See Page 13, lines 5-13; Page 16, lines 5-23; Page 23, lines 5-15; and Page 40, lines 4-21).

As a result of this invention, the resultant structure, including the electrically conductive layer, the copper alloy has relatively large crystal grain sizes and reduced crystal grain boundaries in a current flow direction. Thus, a reduction in electromigration of an interconnection layer in a semiconductor device is produced decreasing the probability of disconnection and cracking of the interconnection layer, thereby improving the reliability and productivity of the semiconductor device. (See Page 6, line 10 - Page 7, line 16; Page 13, lines 17-24; and Page 54, lines 1-10).

II. THE PRIOR ART REJECTION

A. The § 103(a) Rejection over Edelstein, Kato, Oyama, Yamasaki in view of Tsuji First, the references, separately, or in combination, fail to teach, disclose or provide a reason or motivation for being combined. In particular, Edelstein, et al. ("Edelstein") pertains to a copper interconnection structure incorporating a metal seed layer for providing electrical connections with an electronic device where either a copper alloy seed layer or a metal seed layer is sandwiched between a copper conductor body and an electronic device. Edelstein, is focused on "improving the electromigration resistance, the adhesion and the surface properties

of the interconnection structure." (See Edelstein at Abstract; Column 1, lines 5-15; and Column 6, lines 10-23).

By contrast, Kato, et al. ("Kato") does not have the same aim as Edelstein. Instead Kato pertains to a copper alloy with a composition of Mg, P and Sb used to increase the electroconductivity, tensile strength and bending resistance of conductors, e.g, electric wires in equipment. (See Kato at Abstract).

Nothing within Kato suggests a copper interconnection structure with improved electromigration resistance, adhesion and surface properties as disclosed in Edelstein. Thus, Edelstein teaches away from being combined with another invention, such as, Kato.

By contrast, Oyama, et al. ("Oyama") does not have the same aim as either Edelstein or Kato. Instead Oyama pertains to a copper alloy with a composition of Ti, Ni and Sn used to increase the migration resistance, electroconductivity, and strength for electronic parts, e.g, connectors. (See Oyama at Abstract).

Nothing within Oyama suggests a copper interconnection structure with improved electromigration resistance, adhesion and surface properties as disclosed in Edelstein. Further, nothing within Oyama suggests conductors, e.g., electric wires, with improved electroconductivity, tensile strength and bending resistance as disclosed in Kato. Thus, Edelstein teaches away from being combined with another invention, such as, Kato or Oyama.

By contrast, Yamasaki, et al. ("Yamasaki") does not have the same aim as Edelstein, Kato or Oyama. Please note that the Examiner confirmed by telephone that the reference "Yamazaki" in the Office Action is actually "Yamasaki" with U.S. Patent Number 4,559,200. Instead, Yamasaki pertains to a copper alloy with a composition which includes Ti and Fe used to increase the heat resistance, heat conductivity, and mechanical strength for lead frames

of electronic parts, e,g., heat exchanger fins. (See Yamasaki at Abstract; Column 1, lines 5-15; and Column 2, lines 10-31 and lines 53-60).

Nothing within Yamasaki suggests a copper interconnection structure with improved electromigration resistance, adhesion and surface properties as disclosed in Edelstein. Further, nothing within Yamasaki suggests conductors, e.g., electric wires, with improved electroconductivity, tensile strength and bending resistance as disclosed in Kato. In addition, nothing within Yamasaki suggests electronic parts, e.g. connectors with improved migration resistance, electroconductivity, and strength as disclosed in Oyama. Thus, Edelstein teaches away from being combined with another invention, such as, Kato, Oyama or Yamasaki.

By contrast, Tsuji, et al. ("Tsuji") does not have the same aim as Edelstein, Kato, Oyama or Yamasaki. Instead Tsuji pertains to improving the strength and heat resistance of the leads of a film carrier by reducing their thickness and eliminating the anisotropy, i.e., unequalness, of their mechanical properties. (See Column 3, lines 26-37). Accordingly, Tsuji teaches that the rolled copper foil is made of copper alloy compositions where the copper foil is photo-etched to provide copper inner leads and outer leads with testing pads. Both the inner leads and the outer leads form an interface between external circuits and electrode terminals of a semiconductor chip. (See Column 1, lines 20-25 and lines 48-68; Column 2, lines 8-17; Column 3, lines 52-58; and Figure 1).

Nothing within Tsuji suggests a copper interconnection structure with improved electromigration resistance, adhesion and surface properties as disclosed in Edelstein. Further, nothing within Tsuji suggests conductors, e.g., electric wires, with improved electroconductivity, tensile strength and bending resistance as disclosed in Kato. In addition, nothing within Tsuji suggests electronic parts, e.g. connectors with improved migration

resistance, electroconductivity, and strength as disclosed in Oyama. Further, nothing within Tsuji suggests lead frames of electronic parts with improved heat resistance, heat conductivity, and mechanical strength as disclosed in Yamasaki. Thus, Edelstein teaches away from being combined with another invention, such as, Kato, Oyama, Yamasaki or Tsuji.

Therefore, one of ordinary skill in the art would not have combined these references, absent hindsight. It is clear that the Examiner has simply read Applicant's specification and conducted a keyword search to yield Edelstein, Kato, Oyama, Yamasaki and Tsuji. The Examiner provides no motivation or reason to combine other than to assert that it would have been obvious to one having ordinary skill in the art at the time in practicing Edelstein to employ suitable copper alloys including various elements with suitable amounts as "such alloys are conventional and advantageous where appropriate amounts would result in improved copper alloys as evidenced by Kato, Oyama, Yama[s]aki and Tsuji." Such an assertion does not take into account the distinct structural differences of the five inventions as indicated above, and further discussed below. Thus, the Examiner's conclusion attempts to solve a problem which may not exist with Edelstein, Kato, Oyama, Yamasaki or Tsuji.

First, as a result of the Examiner's keyword search, Applicant notes that no less than five references have been "kluged" together using impermissible hindsight to yield Applicant's invention. This on its face clearly strains the reasonableness of what "would have been obvious" at the time of Applicant's invention.

Secondly, Edelstein does not teach or suggest the features of independent claim 1 and similar claims 58-61, including at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and

wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. Edelstein also does not teach or suggest the features of similar independent claim 12, including the copper alloy further includes at least one of Ge and Mg in a range of not less than 0.1 percent by weight to not more than a maximum solubility limit of copper. Edelstein further does not teach or suggest the features of similar independent claim 22, including wherein the copper alloy further includes at least one of Ge and Mg in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

Rather Edelstein discloses, in part, a copper interconnection structure incorporating a metal seed layer for providing electrical connections with an electronic device where either a copper alloy seed layer or the metal seed layer of Ag, Mo, W, or Co is sandwiched between a copper conductor body and an electronic device. (See Edelstein at Abstract; Column 1, lines 5-13; and Column 6, lines 10-23). Edelstein teaches that copper alloy seed layers may be formed from a variety of elements, including Ag, Si, Ti and P as well as Cr, Ni, Ge and Mg. (See Column 8, lines 30-55). However, Edelstein does not provide any percentage of weight of the alloy elements, let alone a percentage of weight of not less than 0.1 percent by weight. Edelstein, accordingly, does not teach a copper alloy, which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

Indeed, the Examiner indicates in the Office Action that Edelstein does not claim any specific amounts of the elements but attempts to rely on four other references to provide these amounts. (See Office Action at Page 3, 3rd Paragraph).

Edelstein also teaches that the copper seed layer, or the metal seed layer of Ag, Mo, W or Co, has a thickness in the range of 0.1 nm-100 nm but does not disclose any percent by weight for any of these elements in the alloy, or any of the other disclosed elements, including Ti, let alone the critical percentage weight range of Applicant's invention. (See Column 9, lines 38-45). As indicated, Applicant's invention discloses that the copper alloy also includes at least one of Mo, Ta, and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. Applicant, accordingly, indicates that this range is critical to the invention as previously discussed above. In particular, the presence of any of these elements in the copper alloy greater than 1 percent causes the resistivity of the copper alloy to be too high and the resistance of the interconnection to be too high. (See Page 40, lines 4-7).

Similarly, the presence of these elements in the copper alloy less than 0.1 percent by weight has the effect of insufficiently suppressing the mass-transfer of copper through the copper, which results in disconnection and cracking of the interconnection and insufficient reliability of the semiconductor device containing the interconnection. (See Page 40, lines 8-21). Thus, Applicant disagrees with the assertion in the Office Action that Edelstein's copper alloy seed layer or metal seed layer can be used to produce Applicant's invention.

Consequently, Edelstein's conventional structure is also unsuitable for achieving at least two objects of the invention, which include effectively producing a copper alloy with relatively large crystal grain sizes and reduced crystal grain boundaries in a current flow direction which suppress the mass-transfer of copper through the copper alloy and prevents the resistivity of the copper alloy from becoming too high. (See Page 6, line 10 - Page 7, line 16; Page 13, lines 5-13 and 17-24; Page 16, lines 5-23; Page 23, lines 5-15; Page 40, lines 4-21; and Page 54, lines 1-10). Edelstein, therefore, does not teach, suggest or disclose a copper alloy as recited in independent claims 1, 12, 22 and 58-61

Third, Kato does not make up for the deficiencies of Edelstein. Instead, Kato discloses a conventional copper alloy with a composition of Mg, P and Sb used to increase the electroconductivity, tensile strength and bending resistance of conductors, e.g, electric wires in equipment. (See Kato at Abstract).

In contrast, Applicant's invention as disclosed above, which includes a specific composition of elements, including Mo, Ta or W and at least one of Cr and Ni, at the specific percent by weights recited are different than the composition of Mg, P and Sb, without Mo, Ta, W, Cr or Ni, in a range of 0.01-0.5 percent by weight as recited in Kato. Accordingly, Kato does not teach a copper alloy, which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

Consequently, Kato's conventional structure is also unsuitable for achieving at least two objects of the invention as indicated above, and thus does not disclose, teach or suggest the invention.

Fourth, Oyama does not make up for the deficiencies of Edelstein. Instead, Oyama discloses a conventional copper alloy with a composition of of Ti, Ni and Sn in a range of 0.1-3.0 percent by weight with minor elements of Fe, Cr, Co, Zr, Mg and Si at about 0.5 percent by weight used to increase the migration resistance, electroconductivity, and strength for electronic parts, e.g, connectors. (See Oyama at Abstract).

In contrast, Applicant's invention as disclosed above, which includes a specific composition of elements, including Mo, Ta or W, at the specific percent by weights recited are different than the composition of Ti, Ni and Sn with minor elements, but without Mo, Ta

or Wi, in a range of 0.1-3.0 percent by weight as recited in Oyama. Accordingly, Oyama does not teach a copper alloy, which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

Consequently, Oyama's conventional structure is also unsuitable for achieving at least two objects of the invention as indicated above, and thus does not disclose, teach or suggest the invention.

Fifth, Yamasaki does not make up for the deficiencies of Edelstein. Instead, Yamasaki discloses a conventional copper alloy with a composition of Fe and Ti in a range of 0.1-2.6 percent by weight with minor elements of Mg, Sb, V, Zr, In , Zn, Sn, Ni, Al and P at about 0.005-0.5 percent by weight used to increase the heat resistance, heat conductivity, and mechanical strength for lead frames of electronic parts, e.g, heat exchanger fins. (See Yamasaki at Abstract; Column 1, lines 5-14; and Column 2, lines 10-31).

In contrast, Applicant's invention as disclosed above, which includes a specific composition of elements, including Mo, Ta or W, at the specific percent by weights recited are different than the composition of Ti and Fe with minor elements, but without Mo, Ta or W, in a range of 0.1-2.6 percent by weight as recited in Yamasaki. Accordingly, Yamasaki does not teach a copper alloy, which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

Consequently, Yamasaki's conventional structure is <u>also unsuitable for achieving at least two objects</u> of the invention as indicated above, and thus does not disclose, teach or suggest the invention.

Finally, Tsuji does not <u>make up for the deficiencies of Edelstein</u>. Instead, Tsuji discloses a conventional method for manufacturing a film carrier including rolled copper foil made of a copper alloy composition where the copper foil is photo-etched to provide copper inner leads and outer leads with testing pads. Both the inner leads and the outer leads form an interface between external circuits and electrode terminals of a semiconductor chip. (See Column 1, lines 20-25 and lines 48-68; Column 2, lines 8-17; Column 3, lines 52-58; and Figure 1). The copper alloy consists of one or more elements, including Ag, As, P and Si at 0.05-0.2 wt % but <u>not</u> Mo, Ta or W nor Ge, used to <u>increase the heat resistance and improve the strength</u> of copper leads while reducing thickness of the leads. (See Yamasaki at Abstract; Column 1, lines 5-14; and Column 2, lines 10-31). (See Application, Page 24, lines 18-24; and Tsuji, Column 3, lines 26-37).

In contrast, Applicant's invention as disclosed above, which includes a specific composition of elements, <u>including Mo, Ta or W, and at least one of Ge and Mg</u>, at the specific percent by weights recited are different than the copper alloy composition <u>without</u> Mo, Ta W nor Ge as recited in Tsuji. Accordingly, Tsuji does <u>not</u> teach <u>a copper alloy, which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.</u>

Consequently, Tsuji's conventional method and related structure is also unsuitable for achieving at least two objects of the invention as indicated above, and thus does not disclose, teach or suggest the invention

For at least the reasons outlined above, Applicant respectfully submits that Edelstein, Kato, Oyama, Yamasaki or Tsuji, separately or in combination, do not teach or suggest all of the features of independent claims 1, 12, 22, and 57-61, and related dependent claims 2, 4, 6-11, 15-21, 23-25, 28-37, and 62-63. These claims are patentable not only by virtue of their dependency from their independent claims but also by the additional limitations they recite.

For the reasons stated above, the claimed invention is fully patentable over the cited references.

B. The § 103(a) Rejection over Dubin, Kato, Oyama, Yamasaki in view of Tsuji

First, the references, separately, or in combination, fail to teach, disclose or provide a reason or motivation for being combined. In particular, Dubin ("Dubin") pertains to, in part, a copper or copper alloy interconnection pattern formed by a damascene technique where aluminum or magnesium alloy is deposited in a damascene opening formed in a dielectric layer. Copper or a copper alloy is electroplated or electrolessly plated on the aluminum or magnesium alloy. (See Dubin at Abstract; Column 1, lines 5-10). Dubin is focused on "forming a self-encapsulated oxide on the Cu or Cu alloy to improve corrosion resistance of the interconnection patterns while substantially reducing or eliminating Cu diffusion." (See Dubin at Abstract; Column 3, lines 55-62).

By contrast, Kato, et al. ("Kato") does not have the same aim as Dubin. Instead Kato pertains to a copper alloy with a composition of Mg, P and Sb used to increase the electroconductivity, tensile strength and bending resistance of conductors, e.g, electric wires in

equipment. (See Kato at Abstract).

Nothing within Kato suggests a copper interconnection structure encapsulated with aluminum or magnesium with improved corrosion resistance and substantially reduced Cu diffusion as disclosed in Dubin. Thus, Dubin teaches away from being combined with another invention, such as, Kato.

By contrast, Oyama, et al. ("Oyama") does not have the same aim as either Dubin or Kato. Instead Oyama pertains to a copper alloy with a composition of Ti, Ni and Sn used to increase the migration resistance, electroconductivity, and strength for electronic parts, e.g, connectors. (See Oyama at Abstract).

Nothing within Oyama suggests a copper interconnection structure encapsulated with aluminum or magnesium with improved corrosion resistance and substantially reduced Cu diffusion as disclosed in Dubin. Further, nothing within Oyama suggests conductors, e.g., electric wires, with improved electroconductivity, tensile strength and bending resistance as disclosed in Kato. Thus, Dubin teaches away from being combined with another invention, such as, Kato or Oyama.

By contrast, Yamasaki, et al. ("Yamasaki") does not have the same aim as Dubin, Kato or Oyama. Instead, Yamasaki pertains to a copper alloy with a composition which includes Ti and Fe used to increase the heat resistance, heat conductivity, and mechanical strength for lead frames of electronic parts, e,g., heat exchanger fins. (See Yamasaki at Abstract; Column 1, lines 5-15; and Column 2, lines 10-31 and lines 53-60).

Nothing within Yamasaki suggests a copper interconnection structure encapsulated with aluminum or magnesium with improved corrosion resistance and substantially reduced Cu diffusion as disclosed in Dubin. Further, nothing within Yamasaki suggests conductors,

e.g., electric wires, with improved electroconductivity, tensile strength and bending resistance as disclosed in Kato. In addition, nothing within Yamasaki suggests electronic parts, e.g., connectors with improved migration resistance, electroconductivity, and strength as disclosed in Oyama. Thus, Dubin teaches away from being combined with another invention, such as, Kato, Oyama or Yamasaki.

By contrast, Tsuji, et al. ("Tsuji") does not have the same aim as Dubin, Kato, Oyama or Yamasaki. Instead Tsuji pertains to improving the strength and heat resistance of the leads of a film carrier by reducing their thickness and eliminating the anisotropy, i.e., unequalness, of their mechanical properties. (See Column 3, lines 26-37). Accordingly, Tsuji teaches that the rolled copper foil is made of copper alloy compositions where the copper foil is photo-etched to provide copper inner leads and outer leads with testing pads. Both the inner leads and the outer leads form an interface between external circuits and electrode terminals of a semiconductor chip. (See Column 1, lines 20-25 and lines 48-68; Column 2, lines 8-17; Column 3, lines 52-58; and Figure 1).

Nothing within Tsuji suggests a copper interconnection structure encapsulated with aluminum or magnesium with improved corrosion resistance and substantially reduced Cu diffusion as disclosed in Dubin. Further, nothing within Tsuji suggests conductors, e.g., electric wires, with improved electroconductivity, tensile strength and bending resistance as disclosed in Kato. In addition, nothing within Tsuji suggests electronic parts, e.g. connectors with improved migration resistance, electroconductivity, and strength as disclosed in Oyama. Further, nothing within Tsuji suggests lead frames of electronic parts with improved heat resistance, heat conductivity, and mechanical strength as disclosed in Yamasaki. Thus, Dubin teaches away from being combined with another invention, such as, Kato, Oyama, Yamasaki

or Tsuji.

Therefore, one of ordinary skill in the art would not have combined these references, absent hindsight. It is clear that the Examiner has simply read Applicant's specification and conducted a keyword search to yield Dubin, Kato, Oyama, Yamasaki and Tsuji. The Examiner provides no motivation or reason to combine other than to assert that it would have been obvious to one having ordinary skill in the art at the time in practicing Dubin to employ suitable copper alloys including various elements with suitable amounts as "such alloys are conventional and advantageous where appropriate amounts would result in improved copper alloys as evidenced by Kato, Oyama, Yama[s]aki and Tsuji." Such an assertion does not take into account the distinct structural differences of the five inventions as indicated above, and further discussed below. Thus, the Examiner's conclusion attempts to solve a problem which may not exist with Dubin, Kato, Oyama, Yamasaki or Tsuji.

First, as a result of the Examiner's keyword search, Applicant notes that no less than five references have been "kluged" together using impermissible hindsight to yield Applicant's invention. This on its face clearly strains the reasonableness of what "would have been obvious" at the time of Applicant's invention

Secondly, Dubin does not teach or suggest the features of independent claim 1 and similar claims 58-61, including at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. Dubin also does not teach or suggest the features of similar independent claim 12, including the copper alloy further

includes at least one of Ge and Mg in a range of not less than 0.1 percent by weight to not more than a maximum solubility limit of copper. Dubin further does not teach or suggest the features of similar independent claim 22, including wherein the copper alloy further includes at least one of Ge and Mg in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

Rather Dubin discloses, in part, a copper or copper alloy interconnection pattern formed by a damascene technique where aluminum or magnesium alloy is deposited in a damascene opening formed in a dielectric layer. Copper or a copper alloy is electroplated or electrolessly plated on the aluminum or magnesium alloy. (See Dubin at Abstract; Column 1, lines 5-10). Dubin teaches that the copper alloy seed layer may be formed from a variety of elements, including Ag, Mg, Sn, Zn, Pd, Au, Zr and Ni. However, Dubin does not disclose, teach or suggest any percent by weight of any of these elements, let alone the percentage range of Applicant's invention. Instead Dubin only teaches a thickness range of an alloy diffusion layer. (See Column 5, lines 45-60; Column 9, lines 38-45). Dubin, accordingly, does not teach a copper alloy, which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. (See Column 5, line 66; Column 6, lines 48-50 and Column 8, lines 30-45).

As indicated, Dubin also teaches a diffusion barrier layer composed of a variety of elements and alloys, in particular, Ta, Ta alloys, Wa, W as alloys, Si, Ti and Ti alloys. (See Column 7, lines 13-18). However, these elements and alloys comprise a diffusion barrier layer to protect against diffusion of Cu atoms from the Cu metallization though dielectric layer not

an electrically conductive layer as disclosed in Applicant's invention, let alone an electrically conductive layer composed of a copper alloy as indicated in claim 12 of Applicant's invention. Dubin also does not disclose any percent by weight of any of these elements, let alone the percentage range of Applicant's invention. Instead, Dubin discloses a thickness range of 50-1,500Å (See Column 5, lines 5-20 and lines 45-60). As indicated, Applicant's invention discloses that the copper alloy includes at least one of Mo, Ta, and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. Applicant, accordingly, indicates that this range is important to the invention as discussed above. Absent these elements falling within this range either the resistivity of the copper alloy and interconnection becomes too high, i.e., when the percent by weight of the elements in the composition are greater than one percent, or the mass-transfer of copper through the copper is insufficiently suppressed, i.e., when the percent by weight of the elements in the composition are less than 0.1 percent, which results in disconnection and cracking of the interconnection yielding insufficient reliability of the semiconductor device containing the interconnection. (See Page 40, lines 4-21).

Thus, Applicant disagrees with the assertion in the Office Action that Dubin's copper alloy seed layer or diffusion layer can be used to produce Applicant's invention. Consequently, Dubin's conventional structure is also unsuitable for achieving at least two objects of the invention, which include effectively producing a copper alloy with relatively large crystal grain sizes and reduced crystal grain boundaries in a current flow direction which suppress the mass-transfer of copper through the copper alloy and prevents the resistivity of the copper alloy from becoming too high. (See Page 6, line 10 - Page 7, line 16; Page 13, lines 5-13 and 17-24; Page 16, lines 5-23; Page 23, lines 5-15; Page 40, lines 4-21; and Page 54, lines 1-10). Dubin, therefore, does not disclose, teach or suggest a copper alloy, which

includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. Dubin further does not disclose, teach or suggest the copper alloy as disclosed in claims 12 and 22.

Indeed, the Examiner indicates in the Office Action that Dubin does not claim any specific amounts of the elements but attempts to rely on four other references to provide these amounts. (See Office Action at Page 3, 3rd Paragraph).

Third, Kato does not make up for the deficiencies of Dubin. Instead, Kato discloses a conventional copper alloy with a composition of Mg, P and Sb used to increase the electroconductivity, tensile strength and bending resistance of conductors, e.g, electric wires in equipment. (See Kato at Abstract).

In contrast, Applicant's invention as disclosed above, which includes a specific composition of elements, including Mo, Ta, or W, and at least Cr or Ni, at the specific percent by weights recited are different than the composition of Mg, P and Sb, without Mo, Ta, W, Cr or Ni, in a range of 0.01-0.5 percent by weight as recited in Kato. Accordingly, Kato does not teach a copper alloy, which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

Consequently, Kato's conventional structure is also unsuitable for achieving at least

two objects of the invention as indicated above, and thus does not disclose, teach or suggest the invention.

Fourth, Oyama does not make up for the deficiencies of Dubin. Instead, Oyama discloses a conventional copper alloy with a composition of of Ti, Ni and Sn in a range of 0.1-3.0 percent by weight with minor elements of Fe, Cr, Co, Zr, Mg and Si at about 0.5 percent by weight used to increase the migration resistance, electroconductivity, and strength for electronic parts, e.g, connectors. (See Oyama at Abstract).

In contrast, Applicant's invention as disclosed above, which includes a specific composition of elements, including Mo, Ta or W, at the specific percent by weights recited are different than the composition of Ti, Ni and Sn with minor elements, but without Mo, Ta or W, in a range of 0.1-3.0 percent by weight as recited in Oyama Accordingly, Oyama does not teach a copper alloy, which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

Consequently, Oyama's conventional structure is also unsuitable for achieving at least two objects of the invention as indicated above, and thus does not disclose, teach or suggest the invention.

Fifth, Yamasaki does not make up for the deficiencies of Dubin. Instead, Yamasaki discloses a conventional copper alloy with a composition of Fe and Ti in a range of 0.1-2.6 percent by weight with minor elements of Mg, Sb, V, Zr, In , Zn, Sn, Ni, Al and P at about 0.005- 0.5 percent by weight used to increase the heat resistance, heat conductivity, and

mechanical strength for lead frames of electronic parts, e.g, heat exchanger fins. (See Yamasaki at Abstract; Column 1, lines 5-14; and Column 2, lines 10-31).

In contrast, Applicant's invention as disclosed above, which includes a specific composition of elements, including Mo, Ta or Wi, at the specific percent by weights recited are different than the composition of Ti and Fe with minor elements, but without Mo, Ta or W, in a range of 0.1-2.6 percent by weight as recited in Yamasaki. Accordingly, Yamasaki does not teach a copper alloy, which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

Consequently, Yamasaki's conventional structure is also unsuitable for achieving at least two objects of the invention as indicated above, and thus does not disclose, teach or suggest the invention.

Finally, Tsuji does not make up for the deficiencies of Dubin. Instead, Tsuji discloses a conventional method for manufacturing a film carrier including rolled copper foil made of a copper alloy composition where the copper foil is photo-etched to provide copper inner leads and outer leads with testing pads. Both the inner leads and the outer leads form an interface between external circuits and electrode terminals of a semiconductor chip. (See Column 1, lines 20-25 and lines 48-68; Column 2, lines 8-17; Column 3, lines 52-58; and Figure 1). The copper alloy consists of one or more elements, including Ag, As, P and Si at 0.05-0.2 wt % but not Mo, Ta or W nor Ge, used to increase the heat resistance and improve the strength of copper leads while reducing thickness of the leads. (See Yamasaki at Abstract; Column 1,

lines 5-14; and Column 2, lines 10-31). (See Application, Page 24, lines 18-24; and Tsuji, Column 3, lines 26-37).

In contrast, Applicant's invention as disclosed above, which includes a specific composition of elements, including Mo, Ta, or W, and Ge, at the specific percent by weights recited are different than the copper alloy composition without Mo, Ta W nor Ge as recited in Tsuji. Accordingly, Tsuji does not teach a copper alloy, which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, wherein the copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and wherein the copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percént by weight.

Consequently, Tsuji's conventional method and related structure is also unsuitable for achieving at least two objects of the invention as indicated above, and thus does not disclose, teach or suggest the invention.

For at least the reasons outlined above, Applicant respectfully submits that Dubin, Kato, Oyama, Yamasaki or Tsuji, separately or in combination, do not teach or suggest all of the features of independent claims 1, 12, 22, and 57-61, and related dependent claims 2, 4, 6-11, 15-21, 23, 25, 28-37, and 62-63. These claims are patentable not only by virtue of their dependency from their independent claims but also by the additional limitations they recite.

For the reasons stated above, the claimed invention is fully patentable over the cited references.

III. FORMAL MATTERS AND CONCLUSION

In view of the foregoing, Applicant submits that claims 1, 2, 4, 6-12, 15-25, 28-37, and 57-64 all the claims presently pending in the application are patentably distinct over the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

The Commissioner is hereby authorized to charge any deficiency in fees or to credit any overpayment in fees to Attorney's Deposit Account No. 50-0481.

Respectfully Submitted,

Date: 3/4/03

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the claims:

Claims 3, 5, 13, 14, 26 and 27 are canceled without prejudice or disclaimer.

Please amend the following claims:

1. (Amended) An electrically conductive layer comprising:

a copper alloy which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight,

[wherein said copper alloy has a melting point less than copper]

wherein said copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and

wherein said copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

12. (Amended) An electrically conductive layer comprising:

a copper alloy which includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight,

wherein the mass-transfer of copper is suppressed through said copper alloy[.],

wherein said copper alloy further includes at least one of Ag, As P, Si, Bi, Sb, and Ti in a range of not less than 0.1 percent by weight to not more than a maximum solubility limit to copper, and

wherein said copper alloy further includes at least one of Ge and Mg in a range of not less than 0.1 percent by weight to not more than a maximum solubility limit of copper.

22. (Amended) A semiconductor device comprising:

a semiconductor substrate;

an insulation layer over said semiconductor substrate, and said insulation layer having a trench groove;

a barrier metal layer on a bottom and side walls of said trench groove; and

an electrically conductive layer provided in an interconnection layer on said barrier metal layer, and said interconnection layer filling said trench groove,

wherein said interconnection layer comprises a copper alloy which includes at least one of Ag, As P, Si, Bi, Sb, and Ti in a range of not less than 0.1 percent by weight to not more than a maximum solubility limit to copper, so that said copper alloy is in a solid solution[.],

wherein said copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and

wherein said copper alloy further includes at least one of Ge and Mg in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

57. (Amended) An electrically conductive layer comprising:

a copper alloy which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at more than 0.2 percent by weight,

said copper alloy formed on a substrate of a semiconductor circuit[.],

wherein said copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and

wherein said copper alloy further includes at least one of Cr and Ni in a range of

not less than 0.1 percent by weight to not more than 1 percent by weight.

58. (Amended) An electrically conductive layer comprising:

a copper alloy which includes at least one of Ag, As P, Si, Bi, Sb and Ti at not less than 0.1 percent by weight,

said copper alloy formed on a substrate of a semiconductor circuit[.],

wherein said copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and

wherein said copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

59. (Amended) An electrically conductive layer comprising:

a copper alloy which includes at least one of Ag, As P, Si, Bi, Sb, and Ti in a range of not less than 0.1 percent by weight to not more than a maximum solubility limit to copper, so that said copper alloy is in a solid solution,

said copper alloy formed on a substrate of said semiconductor circuit[.],

wherein said copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and

wherein said copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

60. (Amended) An electrically conductive layer comprising:

a copper alloy which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less

than 0.1 percent by weight and at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight,

wherein said copper alloy has a melting point less than copper and the mass-transfer of copper is suppressed through said copper alloy[.],

wherein said copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and

wherein said copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.

61. (Amended) An electrically conductive layer provided in a semiconductor circuit comprising:

a copper alloy which includes at least one of Ag, As P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight,

said copper alloy provided in a groove within an inter-layer formed on a substrate of said semiconductor circuit[.],

wherein said copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight, and

wherein said copper alloy further includes at least one of Cr and Ni in a range of not less than 0.1 percent by weight to not more than 1 percent by weight.